national accelerator laboratory

Radiation Physics Note #6
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TO: Radiation Physics Staff, RSO's

FROM: S. Baker and P. Neeson

SUBJECT: Fire Extinguisher Hazards

The following is a list of the different types of fire extinguishers that have been used at Fermilab to date. Their characteristics, current utilization, and potential radiation hazards are discussed.

1. CO_2 Fire Extinguisher. The whole container is pressurized with CO_2 for type B and C fires*. The extinguisher is used inside interlocked areas and activated cases have been found. One unit, the most radioactive one** available, was expelled into a 50 gallon empty drum and while the dry ice so produced was subliming, the volume was sampled using the Triton 955B radioactive gas monitor. Since the fire extinguisher had been removed from the radiation area several weeks before the test, the activity was assumed to be entirely due to tritium. The concentration observed was 3 pCi/ml or about 60 per cent of the concentration guide in air for a radiation worker exposed 40 hours a week. Also, traces of ^7Be were found in the residue. Assuming such an extinguisher is expelled inside an interlocked area when its case has reached a radiation level of 10 mR/hr at one foot and the air is breathed for one-half hour thereafter, then the dose received would be less than 1 mrem from the gas. The dose from handling the case in such a situation is estimated to be about 5 mrem.

2. Dry Chemical Multi-Purpose Fire Extinguisher. This fire extinguisher is also called Dry Powder ABC or simply ABC and is used for fighting types A, B, and C fires. The extinguishing agent is mono-ammonium phosphate $NH_4H_2PO_4$ in the form of a fine yellow powder. The impeller is a small CO_2 cartridge or N_2 pressurized gas. The yellow powder easily becomes suspended in air when expelled or even when stirred up. A fire extinguisher of this type got irradiated in the Transfer Hall and a sample of the powder removed after several weeks of radioactive decay. At the time the sample was obtained the radiation level of the case on contact was 5 mR/hr (approximately 0.5 mR/hr at one foot). The powder contained 240 pCi/g ^{22}Na

*Fire classifications are given at the end of this Note.
**Approximately 1 mR/hr at one foot.

and 3000 pCi/g ^{7}Be. This sample was allowed to decay for four months and was irradiated for one week in the Transfer Hall at the east wall by the extraction Lambertson septa. The ^{24}Na concentration corrected back to the end of the irradiation period was 1500 pCi/g, determined using the Ge(Li) detector, and the ^{32}P concentration determined using the sample-changer and an efficiency of 15 per cent, was 8400 pCi/g. The Transfer Hall losses during the irradiation period were typical of those observed over the past four months.

3. Dry Chemical Regular Fire Extinguisher. This fire extinguisher is also called BC and is used in fighting B or C fires. The extinguishing agent is $KHCO_3$ or $NaHCO_3$ and the impeller is a CO_2 or nitrogen gas. $KHCO_3$ is a purple or blue powder and $NaHCO_3$ is a white powder. Most if not all of the BC fire extinguishers at the Laboratory use $KHCO_3$ rather than $NaHCO_3$. $NaHCO_3$ is being phased out. No tests have been made by us to determine the hazards of this type of fire extinguisher. According to Fire Department personnel, CO_2 and ABC (#1 and #2 above) are probably the only ones found in activation areas. They claim that at present the fire hazards in those areas can be handled by using only CO_2 and ABC fire extinguishers.

4. Dry Compound Fire Extinguisher. This fire extinguisher is used in fighting type D or metal fires. The extinguishing agent is a dry, off-white powder called "Met-L-X" compound. The impeller is CO_2. There is essentially no need for this type of fire extinguisher in interlocked areas at the present time and very little need throughout the site. No evaluation of the radiation hazards has been made.

5. Halon Fire Extinguisher. This fire extinguisher is used near expensive computers and data handling equipment on site. The extinguishing agent is Freon 1301 (bromotrifluoromethane) or Freon 1211 (bromodifluorochloromethane) under pressure to act as its own impeller. There are some portable units as well as the permanent installations. No evaluation of the radiation hazards has been made.

6a. Water-filled Fire Extinguisher.
6b. Water plus Carboloid (an antifreeze).

These fire extinguishers are equipped with a hand-operated pump or are pressurized with air or N_2. After a long period of irradiation the water inside this type of fire extinguisher could become too radioactive for drinking purposes; however, the exposure from handling the case would be much greater than the exposure from the water in use for fighting fires.

7. Chemical Foam Fire Extinguisher. This type is being phased out.

8. Soda Acid Fire Extinguisher. This type is being phased out.

Very few of types #7 and #8 are left at Fermilab.

If one assumes that the ABC fire extinguisher (type #2 above) is irradiated in the Transfer Hall for several months until the case reaches a radiation level corresponding to 10 mR/hr at one foot several weeks after the irradiation (Class 3 at the time of use), then its use to fight fires which causes shutdown of the accelerator is estimated to give the following exposures:

A. Exposure from ^{22}Na in the powder would be less than 1 mrem if one assumes 50 mg is inhaled*:

$$0.24 \text{ nCi/g} \times (10 \text{ mR/hr} \div .5 \text{ mR/hr}) \times 50 \text{ mg} \times 5000 \text{ mrem/yr} \div 10{,}000 \text{ nCi} = 0.12 \text{ mrem}$$

where the divisor is the body burden. If one takes into account the biological half-life of sodium in the body for the one-time exposure, the value is further reduced. For ^{32}P the body burden is 6000 nCi and the radioactive decay half-life is 14.28 days. After a few months' irradiation the ^{32}P would reach an activity 3.5 times the one week's irradiation value or about 30 nCi/g. The exposure from ^{32}P assuming 50 mg is inhaled would be about one mrem:

$$30 \text{ nCi/g} \times 50 \text{ mg} \times 5000 \text{ mrem/yr} \div 6000 \text{ nCi} = 1.25 \text{ mrem.}$$

Similar results are obtained for other isotopes.

B. Exposure from handling the fire extinguisher just after shutdown when the dose rate would be about 30 mR/hr at one foot from the case would be greater than 1 mrem and possibly as high as 5 mrem.

SERVICING PROCEDURES

The following information on servicing procedures was obtained from the Fire Department:

1. CO_2 Fire Extinguisher. Weighed at location or brought back to Fire Station. Can be recharged at Fire Station or taken off site for recharging. Must be tested off site every five years.

2. Fire Extinguishers #2, #3, and #4 above (dry powder types). Using CO_2 cartridge, the unit is opened up, the powder inspected, and usually the powder is stirred to ensure that it is not caked. The powder may be replaced or added to as is necessary. If expelled, the CO_2 cartridge goes off site for recharging. Using

*See note at end of report.

N_2 fill (pressurized), the pressure is checked with a pressure meter. In the process the pressure may be relieved thereby expelling some powder.

Type #5 above. Halon fire extinguishers are weighed at location. If refilling is needed, the unit must be taken off site. The fire extinguisher is hydrostatically-tested every five years.

No procedure was obtained for types #6, #7, and #8 above.

Any unit may go off site for pressure testing if the exterior case has been damaged.

CONCLUSIONS

Exposures from CO_2 and Dry Chemical Multi-Purpose (ABC) fire extinguishers will be primarily external exposure from handling the radioactive case. Thus, use of these two types of fire extinguishers inside interlocked areas where radioactivation can occur may continue. It is suggested that only these two types be used in these locations. If other types are needed, an evaluation should be made before they are installed. Fire Department personnel should consult with the Radiation Safety Officer of each radiation area to obtain placement of fire extinguishers in locations where they will get the minimum activation and still provide adequate fire protection.

RECOMMENDATIONS

1. Fire extinguishers of types #1 and #2 (CO_2 and ABC) presently in use inside interlocked areas should continue to be used with no other types added without evaluation by Radiation Physics.

2. Fire extinguishers reaching 10 mR/hr at one foot (Class 3) should be exchanged within the interlocked areas with other less radioactive ones, or relocated to areas where they are less prone to radioactivation.

3. Film badges are required for work on radioactive fire extinguishers. Gloves and face mask are recommended for maintenance which could result in ingestion or external contact with the powder in radioactive ABC fire extinguishers of Class 1. The recommendation is made even though the exposure would be low without gloves and mask because it is likely that a large number of fire extinguishers would be processed by the same person in contrast to the small number used by different people in fighting fires inside interlocked areas. Gloves and face mask are required for similar maintenance of Class 2 ABC fire extinguishers with additional protective clothing such as lab coats recommended.

Powder removed from radioactive fire extinguishers is to be disposed of in the nearest radioactive waste container. Spills must be cleaned up, and personnel should wash their hands after handling the powder.

Such maintenance for Class 3 or higher levels should be postponed until the fire extinguisher has reached Class 2 and then be done under the direct supervision of the RSO or the Radiation Physics Group.

4. Discharging the CO_2 extinguisher for maintenance should be done outside or in a well-ventilated area.

5. If fire extinguishers are removed from interlocked areas, they are to be surveyed by the area RSO or his designee.

6. Before any off site shipment of radioactive fire extinguishers is made, the radioactive contents - powder and/or CO_2 - are to be removed and proper notification and arrangements made with the organization receiving the shipment.

Fire Classifications are as follows:

Class A: ordinary combustibles; wood, paper, cloth, rubbish.

Class B: flammable liquids, oil, paint, gasoline, grease.

Class C: electric equipment, motors, panels, controls, wiring.

Class D: combustible metals, Mg, K, Na, NaK alloys.

Note on internal dose calculations on page 3:

The body burdens used in calculating internal exposures were taken from NBS Handbook 69, for soluble depositions. For ^{22}Na the maximum permissible burden for the total body, 10μCi, is used. For ^{32}P, the maximum permissible burden for bone, 6μCi, is used. In each case the burden for the most critical organ is used.

The internal doses calculated are those that would be received in a year's time, assuming that the initial internal deposition (in μCi) is constantly maintained. Obviously, if physical and biological half-lives are considered, the resultant doses are much less.

The assumed deposition of 50 mg is a liberal estimate based on available data on particle sizes, and respiration and lung retention rates.

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